COMPLEXITY AND AGROFORESTRY: WAYS TO EMBRACE THE CHALLENGE

Paul Burgess[1*], Silvestre Garcia de Jalon[1], and Anil Graves[1]

* Correspondence author: P.Burgess@cranfield.ac.uk

(1) Cranfield University, Cranfield, Bedfordshire, MK43 0AL, UK

Introduction

Existing and recent surveys have highlighted complexity of work as a barrier to the adoption and maintenance of agroforestry in Europe. Compared to agriculture or forestry, agroforestry is more complex at a field-scale. This paper argues that whilst complexity is a constraint to some, it can be embraced by others. The complexity associated with agroforestry can be embraced by supporting new ways for people to work together, by considering wider system boundaries, and by focusing on different productivity measures than yield per unit labour.

Farmer perceptions of the opportunities for and barriers to agroforestry

Agroforestry is the practice of deliberately integrating woody vegetation (trees or shrubs) with crop and/or animal systems to benefit from the resulting ecological and economic interactions (Burgess et al., 2015). It is a significant land use system, for example the LUCAS land use and land cover survey for Europe indicates that trees are integrated with livestock and/or crop production on about 24 million hectares in Europe, equivalent to about 5.7% of the territorial area and about 14% of the agricultural area (den Herder et al. 2015).

Graves et al. (2009) reported the result of interviews with 264 farmers across 14 different regions of Europe in terms of their perception of silvoarable agroforestry systems. The most positive aspects in Northern Europe related to the positive effect of agroforestry on the environment, whilst farmers in Southern Europe primarily recognised the positive benefits in terms of increased profitability. Farmers were then asked to identify the most negative effect of silvoarable systems. Within Northern Europe, the most negatively ranked item was **"work complexity"** followed by "mechanisation". In Southern Europe, the most negative effect of silvoarable agroforestry was the negative effect on intercropped yield.

During 2014, as part of the AGFORWARD agroforestry research project, 45 stakeholder workshops were conducted to identify key barriers and opportunities related to agroforestry in 13 European countries (Denmark, France, Germany, Greece, Hungary, Italy, Netherlands, Portugal, Romania, Spain, Sweden, Switzerland and United Kingdom). Stakeholders included farmers, landowners, agricultural advisors and researchers. During the workshops, 344 stakeholders completed a survey where they ranked the key positive and negative aspects of agroforestry in terms of 45 production, environment, management, and socio-economic issues.

As different approaches were used to evaluate stakeholders' responses across the workshops the responses were standardised between 0 and 1. Thus stakeholders' responses could be used to calculate descriptive statistics and to identify key negative and positive aspects across the case studies. Equation 1 shows the equation used to standardize the values:

$$SS_i = 1 - \frac{S_i - Smin_i}{Smax_i - Smin_i} \qquad (1)$$

Where SS_i and S_i were the standardised and non-standardised scores respectively of participant i and $Smin_i$ and $Smax_i$ were the lowest and highest non-standardised score respectively of participant i. Based on this analysis, the most positive aspects of agroforestry include improved biodiversity and wildlife habitats, improved animal welfare, and soil conservation. The most negative aspect of agroforestry was "**complexity of work**", followed by mechanisation, management costs and administrative burden. It is noteworthy that in both these surveys, the complexity of agroforestry is seen as major constraint. Hence the purpose of this paper is to examine complexity and agroforestry, and approaches to embrace the issue.

Complexity and agroforestry

Complexity is the quality or state of being complex. The Oxford English Dictionary includes definitions for complex such as "consisting of many different and connected parts" and "not easy to analyse of understand". Boulton et al. (2015) describe complexity as being the result of the interconnections of many diverse non-standard components that interact in non-linear ways. Andersson et al. (2014) argues that system complexity can be separated into two different dimensions: complexity and complicatedness (**Figure 9**). Complexity refers to large numbers of

simultaneously interacting entities dynamically giving rise to emergent patterns; it is associated with bottom-up self-organization, e.g. behaviour of a herd or school of fish (Andersson et al. 2014). Andersson et al (2014) defines complicatedness as a property of those systems, typically with some function, where the organisation demands lengthy descriptions. Complicated systems are associated with top-down organization, e.g. engineering (Anderson et al., 2014).

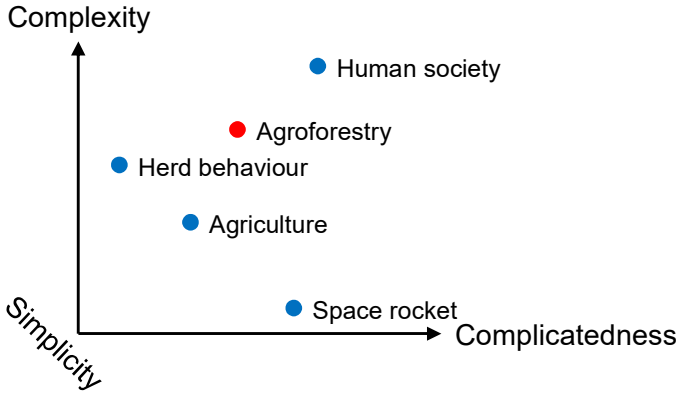

Figure 9: Indicative complexity and complicatedness of five selected systems including agroforestry. Adapted from Anderson et al. (2014).

With agroforestry, the integration of trees or shrubs with arable crops or pastures makes the relationships between biophysical and/or farm-management operations more complicated. For example, the introduction of trees into arable fields, whilst providing an additional source of future revenue in the form of timber, also shades the crop and alters its capture and use of soil water. Whilst the crop-tree interaction if managed correctly may improve the overall economic performance of the farm, agroforestry farmers need to incorporate many more variables in their decision-making processes. This for example includes decisions regarding the orientation and width of tree rows, the timing of field operations, and the potential to damage the tree or crop component. Hence like Anderson (2014), we argue that at a field level, agroforestry is more complex and complicated than agriculture (**Figure 1**).

Approaches to embrace complexity

This section examines some possible mechanisms to address the perceived constraint of the complexity of agroforestry. These include i) thinking differently, ii) new arrangements, iii) alternative attitudes to labour, and iv) consideration of system boundaries.

Thinking differently

In English it is common to identify those people who say that the "glass is half full" and those that say that the "glass is half empty". What some people see a constraint; others can view as an opportunity. Certainly there is some evidence that some people do not see complexity as a constraint. In the analysis of the perception of European farmers of silvoarable systems, Graves et al (2009) reported that the fourth most positive perception of agroforestry was as an opportunity for diversification. In the analysis of the 344 responses from the AGFORWARD project, "Originality and interest" was seen as a key positive management attribute of agroforestry. Some farmers are attracted by the greater ecological knowledge and understanding required to manage an agroforestry system.

New arrangements for working together

One way of dealing with complexity is to involve others who have specific expertise. Within the stakeholder groups of the AGFORWARD project, some farmers have expressed interest in establishing new ways of working with others. For example, if you are the owner of an orchard, what are the best ways of working with someone who is looking for grazing for their sheep? If you are a livestock farmer who has established working hedgerows or high value trees, what are the best ways of working with a skilled forester or agroforester?

Moving beyond yield per unit labour

A key impact of the introduction of mechanisation and specialisation in Western Europe has been a phenomenal increase in labour productivity. Whereas land productivity in the UK increased two-fold between 1950 and 2000, labour productivity increased almost seven-fold (**Table 4**).

Table 4. Levels of agricultural output per unit of land and unit of labour in 1953 and 2000 in the UK (1953=100) (Thirtle and Holding, 2003).

Year	Output per unit land	Output per unit labour
1953	100	100
2000	207	679

Improved labour productivity is essential if workers are to achieve good wages. Although there is a lack of data, it is anticipated that the output of yield per unit labour will tend be lower within an agroforestry system than in specialised agriculture or forestry. Some of this can be explained by different levels of mechanisation, which can be costly, and hence the financial output per investment in labour and machinery may be similar. There appears to be a need for research on the impact of agroforestry and other agro-ecological systems on labour productivity. However two other issues come to mind. First, it is important where possible, for people using agroforestry to secure a higher product price where they can demonstrate environmental and welfare benefits. Secondly it is too simplistic to say that labour is always a cost. Farming is not only a job but it is, for many, a livelihood. Hence time spent tending trees, crops and animals can be valued and enjoyed by the farmer.

Enlarging system boundaries

Conventional agriculture may appear a less complex system than agroforestry if the boundary is drawn at the farm-gate. However it can be argued that large-scale agriculture can become more complex if the system boundary is extended beyond the farm-gate. For example increased runoff associated with a low tree cover may not cause direct problems to the farmer, but it may increase downstream flooding. By internalising some of the complexity within the farm, the use of agroforestry may simplify some of the challenges faced by wider society.

A particular issue of complexity faced by some agroforestry farmers is the administrative complexity of dealing with tree and farming interaction in terms, for example, of claiming basic farm payments within the Common Agricultural Policy. Again better mechanisms to allow farmers and regulators to appropriately deal with the interface between trees and farmers are necessary.

Conclusions

This article proposes that agroforestry systems are complex, i.e. they include related units where the nature of the relationships is imperfectly known. On first sight, this may be off-putting to farmers and managers who value clear responses and outcomes and seek to minimise uncertainty. However to others, agroforestry offers originality and interest and it can create new opportunities for rural employment. Whilst the yield output per unit labour may be lower for agroforestry than agriculture or forestry, this may be counteracted by increased product prices, changed machinery costs and more enjoyable work. Some of the perceived complexity may simply be a result of the choice of system boundary.

Acknowledgements

We acknowledge support of the European Commission through the AGFORWARD FP7 research project (contract 613520). The views and opinions expressed in this report are purely those of the writers and may not in any circumstances be regarded as stating an official position of the European Commission.

References:

Andersson C, Tornberg A, Tornberg P (2014) Societal systems – Complex or worse? Futures 63: 145–157.

Andersson C (2014) Agroforestry Systems. Complex or worse? Chalmers University of Technology, Sweden http://www.slideshare.net/SIANIAgri/clas-andersson.

Boulton JG, Allen PM, Bowman C (2015) Embracing Complexity: Strategic Perspectives for an Age of Turbulence. Oxford University Press, UK, 219 pp.

Burgess PJ, Crous-Duran J, den Herder M, Dupraz C, Fagerholm N, Freese D, Garnett K, Graves AR, Hermansen JE, Liagre F, Mirck J, Moreno G, Mosquera-Losada MR, Palma JHN, Pantera A, Plieninger T, Upson M (2015) AGFORWARD Project Periodic Report: January to December 2014. Cranfield University: AGFORWARD. 95 pp. http://www.agforward.eu/index.php/en/news-reader/id-27-february-2015.html.

den Herder M, Moreno G, Mosquera-Losada R, Palma J, Sidiropouolu A, Santiago Freijanes JJ, Crous Duran J, Paulo J, Tome M, Pantera A, Papanastasis V, Mantzanas K, Pachana P, Burgess PJ (2015) Deliverable D1.2 Current extent and trends of agroforestry in the EU27 including maps. AGFORWARD 613520. 99 pp. http://www.agforward.eu/index.php/en/current-extent-and-trends-of-agroforestry-in-the-eu27.html.

Graves AR, Burgess PJ, Liagre F, Pisanelli A, Paris P, Moreno G, Bellido M, Mayus M, Postma M, Schindler B, Mantzanas K, Papanastasis VP, Dupraz C (2009) Farmer perceptions of silvoarable systems in seven European countries. In: Rigueiro-Rodríguez, A., McAdam, J., Mosquera-Losada, M.R. (Eds). Agroforestry in Europe. Current Status and Future Prospects. Springer.

Thirtle C, and Holding J (2003) Productivity in UK Agriculture: Causes and Constraints. Report to Department for Environment, Food and Rural Affairs. Wye, Kent: Imperial College.